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NORMAL VELOCITY AND CHARACTER OF "BURNING" OF SOME
COMPOUNDS IN THE CATEGORY OF INITIATING EXPLOSIVES

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NORMAL VELOCITY AND CHARACTER OF "BURNING" OF SOME
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-USSR-

[Following is the translation of an article by A. F. Belyayev and A. Ye. Belyayeva entitled "O normal'noy skorosti i kharaktere 'goreniya' nekotorykh initsiirushchikh vzryvchatykh veshchestv" (English version above) in Doklady Akademii Nauk SSSR (Reports of the Academy of Sciences USSR), Vol. LII, No 6, Moscow, 1946, pages 507-509.]

Submitted by Academician N. N. Semenov, 11 February 1946.

We have already been told (1) that fulminate of mercury under high pressure burns in an open space completely steadily with a corresponding small velocity of the order of 1.5 cm/sec. We recall that in the case of uncompressed fulminate of mercury (2) the burning is as a velocity of several meters per second, rapidly changing into a detonation.

The velocity of burning of the highly compressed fulminate of mercury, by analogy with gas combustion, may be called the normal velocity of burning. Note that this velocity is directly dependent on the particular physicochemical properties of the compound and, in particular, on the reaction rate of the chemical change (4).

If the fulminate of mercury is not compressed, then the hot explosive gases enter the pores of the material (5, 6) and the burning process is then complicated and a highly significant role begins to be played by gas dynamical factors. The velocity of flame propagation under those conditions is dependent to a large extent on the gas dynamics of gas jets tearing into the material and the conflagration of the compound under the action of those jets. We have measured the "normal" velocity of burning of a series of other initiating explosive compounds suitable for burning.

All the compounds were compressed under a pressure of 2000 kg/cm² by means of cylinders having a diameter of 4 mm and a height of 6-7 mm. Compression under that pressure ensures a compactness of

of all compounds amounting to 88-95% of specific gravity (of the maximum density).

The curved surface of the cylinders was covered with a thin layer of collodion; this was done to prevent the propagation of the flames on the surface, which may take place at a velocity higher than the velocity of "normal" burning. The ignition of the compounds was produced by a wire made incandescent by a current upon exclusion of certain conditions which shall be discussed separately. The determination of the velocity of burning is done by photographing onto a revolving drum. Here one can use the ordinary light (flame) of the burning charge in the cylinder, or a beam of light from an outside source. This beam at the beginning is enclosed by a cylinder of the explosive compound and because of that, at the end of the burning, it illuminates at all times most of the moving film. The second, "shady" method, showing directly the "disappearance" of the condensed phase, has a number of advantages. The boundary of the illuminated zone one obtains, as one should, very clear and smooth. A comparison of the photographs obtained by each of these methods gives an indirect confirmation of the supposition that the rate determining reaction proceeds in the initiating explosive compounds in the condensed phase, and the flame itself is a secondary process (1).

Here we quote the results obtained by us.

NORMAL VELOCITIES OF BURNING OF SOME INITIATING EXPLOSIVES

Compound	Measured Density	Burning Velocity, cm/sec
Fulminate of mercury	3.80	1.55
Trinitrotri-azobenzol	1.70	0.65
Tricycloacetone peroxide	1.22	0.95
Diazodinitrobenzene	1.45	2.15
Potassium picrate	1.83	1.50
Lead trinitroresorcinol salt (LTNR)	Explodes	-----
Mixture of 40% lead styphnate and 60% talcum	-----	14.5
Mixture of 60% fulminate of mercury and 40% talcum	-----	0.55

We mention, first of all, that on the ignition of the tricycloacetone peroxide with an incandescent wire an explosion takes place (7). We have achieved a steady burning of the peroxide, igniting it with compressed fulminate of mercury. One may presume that the relatively [slow heating ignition wire causes a preliminary warmup of some parts]

of the peroxide which leads to an explosion (8). In addition to the compounds shown in the table, we also tested barium nitride and sodium picrate. Both of these compounds have proved unsuitable for steady burning. Barium nitride burns on 1-2 mm with a velocity of 0.3-0.4 cm/sec and then goes out; sodium picrate on ignition gives a number of separate flashes without formation of steady burning.

All compounds investigated by us, apart from the LTNR [see below] under the conditions mentioned above burn with a comparable velocity and as the photographs show, completely steadily.

We note that the velocity of burning of TNTAB (trinitrotri-azobenzol) was the smallest of all the compounds contained in the table, all of which exceeded by about ten times the velocity of burning of nitrogeletin which, according to the data of Andreyev (9), belongs among the fastest burning secondary explosives. As a rule, all the figures quoted by us are averages of several observations. The best repetition were given by TNTAB and fulminate of mercury.

In the ignition of LTNR (lead trinitroresorcinol salt) with the incandescent wire, an explosion follows with an appreciable mechanical effect. If one should ignite the LTNR with compressed fulminate of mercury, then the explosion does not take place, but a very intense flash is produced. The mixture of 40% LTNR and 60% talcum burns with a velocity of 14.5 cm/sec. Obviously, the velocity of burning of pure LTNR should be higher still. At this velocity of burning on the surface of the burning pellet there should ensue an appreciable pressure increase (5), which should lead to an "explosion" of the steady burning region and to the transformation of burning into a detonation.

If instead of cylinders whose curved surface is coated with collodion, one should take cylinders with uncoated curved surfaces, then, as regards fulminate of mercury and potassium picrate, neither the mechanism nor the velocity of burning is changed. We threw the burning pellets of fulminate of mercury and of potassium picrate into water: the burning would then cease. The burning surface was flat and did not have a conic shape, which is characteristic when the velocity of flame propagation is higher than the "normal" burning velocity.

As regards TNTAB, tricycloacetone peroxide, and diazodinitrophenol without cover, a velocity is established close to the velocity present when there is cover (greater by about 20-30%); therefore, on the surface a jump of flames takes place with a velocity many times greater than the "normal" velocity. If one increases sufficiently the initial temperature of the fulminate of mercury or potassium picrate, then the jump of the flames on the uncovered surface also takes place with these compounds.

Let us consider in general the mode of burning of some of the compounds at pressures less than atmospheric. As was already shown

(1), at pressures of 10-20 mm Hg and less, the fulminate of mercury "burns" without light, with deposition on the walls of the ball of very dirty fulminate of mercury. Potassium picrate loses the ability to burn already at the pressure of 500 mm Hg. In persistent attempts at ignition it gives off a number of flashes, similarly to sodium picrate at atmospheric pressure. The peroxide of tricycloacetone may burn steadily even at a pressure of 40 mm Hg. At 100 mm Hg, a white deposit appears on the walls. If one collects this deposit, then on ignition it swells slightly; however, it is not peroxide, but a substance with a higher melting point and lower volatility. TNTAB burns steadily even at a pressure of 10 mm Hg. Its characteristic property is also the presence of flames at very low pressures. As the pressure decreases, the flame at first gets fainter and stretches. Then the flame decreases in size. At 10 mm Hg, the flame is very faint and small.

Thus, burning at decreased pressure in the case of all investigated substances is characterized by the separate respective distinguishing features.

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